WHEN LIVESTOCK ARE GOOD FOR THE ENVIRONMENT: BENEFIT-SHARING OF ENVIRONMENTAL GOODS AND SERVICES[1]

Robin Mearns[2]

Summary

Livestock producers are coming in for increasing criticism world-wide on the grounds that livestock production is bad for the environment. Mention 'cattle' and 'developing countries' in the same breath, and many will immediately think of overgrazing, desertification, and deforestation. But the environmental consequences of livestock production vary widely, depending on the opportunities and constraints afforded by different production systems, institutional and policy contexts. Focusing principally on pastoral grazing systems and integrated crop-livestock systems, this paper examines the less widely documented case that there are also positive environmental externalities associated with livestock production. Livestock production can play an instrumental role, for example, in supporting sustainable rangeland management, preserving wildlife and other forms of biodiversity, enhancing soil fertility and nutrient cycling, and in directly promoting the amenity value of particular landscapes to other users.

The environments in which most pastoral grazing systems and integrated crop-livestock systems are to be found are characterised by multiple uses and multiple users, all with legitimate claims on environmental goods and services, but not all of which can be compatible all of the time. The paper addresses ways of enhancing, through policy instruments, the sharing of environmental benefits between multiple users of the environment including livestock producers. It argues that the task of policy makers should be to expose these multiple, contested claims on the environment, to make explicit the political choices involved in the design of benefit-sharing mechanisms, and to seek out those that offer most promise of 'win-win' or at least 'win-no regret' solutions.

---

[1] Invited special paper for the World Bank/FAO Workshop, 'Balancing Livestock and the Environment', Washington, DC, September 27-28, 1996, an associated event to the Fourth World Bank Conference on Environmentally Sustainable Development. The author is grateful for the financial support of FAO and the World Bank for the preparation of this paper, and for comments made by Cees de Haan, Simon Maxwell, Ian Scoones, Brent Swallow, Jeremy Swift, and workshop participants. None of these individuals and institutions is responsible for any errors which may remain.

[2] Robin Mearns is a Fellow of the Institute of Development Studies, and a founder member of the IDS Environment Group.

INTRODUCTION

More than half of the world's land surface is used for livestock production, encompassing landscapes of extraordinary natural beauty and of global importance to the biosphere. The environmental consequences of livestock production vary widely, depending on the opportunities and constraints afforded by different production systems, institutional and policy contexts. But it is now increasingly recognised that such environments are characterised by multiple uses and multiple users, all with legitimate claims on goods and services derived from the environment. These claims cannot be compatible with one another all of the time, and relationships among competing claimants can at times become highly conflictual. The notion of 'benefit sharing' is here understood to refer to the fact that goods and services derived from the environment provide benefits to a wide range of potential users, among them livestock producers, which need to be balanced. But since balancing contested claims is inherently a political act, the 'appropriate' distribution of environmental benefits among users cannot be defined objectively. The task of policy analysts must be to expose these multiple, contested claims on environmental goods and services; to make explicit the political choices involved in the design of instruments and mechanisms for benefit sharing; and to seek out those that offer most promise of 'win-win' or at least 'win-no regret' solutions.

MARKET FAILURE IN DISTRIBUTION OF ENVIRONMENTAL BENEFITS

The prices paid for livestock products world-wide fail to reflect fully the environmental costs associated with their production. Government subsidies of various kinds, whether for animal feed, for land clearance, or for fossil fuel energy used in industrial livestock rearing, and tariff barriers to trade in livestock products, yet further distort market prices and exacerbate the environmental costs of livestock produced under certain conditions. The consequences are well documented:

> Rings of barren earth spread out from wells on the grasslands of [former] Soviet Turkmenia. Heather and lilies wilt in the nature preserves of the southern Netherlands. Forests teeming with rare forms of plant and animal life explode in flame in Costa Rica. Water tables fall and fossil fuels are wasted in the United States. Each of these cases of environmental decline issues from a single source: the global livestock industry. (Durning and Brough 1991: 5)

It is less widely appreciated, however, that there are also positive environmental externalities associated with livestock production, which go equally unaccounted in market prices for livestock products. In a wide range of livestock production systems, from pastoral grazing systems to integrated crop-livestock systems, livestock production confers certain environmental benefits which are not well captured by the market mechanism. In some cases the underlying causal processes are not well understood by policy makers and, as a result, livestock producers are wrongly castigated for environmental problems that could be avoided with more appropriate institutional, pricing and policy arrangements. It is the purpose of this paper to elaborate on some of the positive environmental externalities associated with livestock production, and to suggest ways that these benefits may be enhanced through policy instruments and shared with other claimants on environmental goods and services.

A narrow view of the economy considers only the direct, marketed flows of goods and services from economic production to consumption, and the return flow of labour to economic production. It ignores the underlying natural resource stocks and flows and ecological functioning services which sustain economic production and human well-being. While livestock production generates outputs such as meat, milk, skins and hides, fuel energy and draught power, on this wider view it also entails many positive externalities including landscape, environmental and species amenity values, waste assimilation, and ecological functions such as nutrient cycling and the maintenance of certain conditionally-renewable resource stocks.

Placing values on these positive environmental externalities allows for a sounder analysis of the economic benefits, as well as costs, of livestock production:

Total economic value = direct use value (e.g. livestock products, landscape amenity)
+ ecological function value (e.g. nutrient cycling, favouring seed germination)
+ option value (e.g. animal genetic diversity)
+ existence value (e.g. satisfaction that domesticated herbivores are there)

Efficient and sustainable resource pricing follows both the polluter (user)-pays principle and the beneficiary-compensates principle (Young 1992). The latter recognises that livestock production can provide positive environmental benefits and even increase future options, including actions that improve or maintain landscape and biodiversity values and provide environmental services. On this principle, if livestock producers perform additional actions (including forgoing production) to help to maintain highly valued landscapes as diverse as alpine meadows, the Hell's Canyon in Oregon[3], and African savannas, they should be compensated by the recreational beneficiaries for the ongoing costs of landscape maintenance that do not bring market benefits and are not required of all people.

For example, the opportunity cost of wildlife biodiversity conservation in protected areas of Kenya, measured in terms of forgone livestock and agricultural production, has been estimated to be around $203 mn/yr, or 2.8 per cent of total GDP, while revenues from wildlife tourism and forestry contribute only around $42 mn/yr to the national economy (Norton-Griffiths and Southey 1995). The authors argue that, given the global nature of the benefits of Kenya's conservation efforts, it is quite inappropriate that so much of the cost is borne by Kenya alone. It will be argued below that wildlife conservation and livestock production are potentially more complementary than this case suggests, but the point remains that the amenity and option values of biodiversity should be fully reflected in the prices paid by those who make use of these benefits, and should be used to compensate those who bear the additional costs of providing them.

[3] See Krutilla and Cicchetti (1972) for an early study evaluating the benefits of recreational uses of the Hell's Canyon, at a time when the major perceived threat to landscape amenity and biodiversity was proposed development for hydroelectric power generation, rather than livestock production which is perceived by the environmental lobby as the major threat today.

Types and overall significance of livestock production systems

Grazing systems are based almost exclusively on livestock kept on rangelands (i.e. unimproved grasslands, shrublands, savannas, deserts and tundra), with no or only limited integration with crops and relying little on imported inputs (Steinfeld et al. 1996). Of all livestock production systems, grazing systems are the most likely to coincide geographically with areas of high value for wildlife and other forms of biodiversity. Rangelands occupy 51 per cent of the earth's land surface (almost 90 per cent of agricultural land in Africa, West and Central Asia, and Latin America, and over 60 per cent of agricultural land elsewhere in Asia), contain about 36 per cent of its total carbon in living and dead biomass, include a large number of economically important species and ecotypes, support 50 per cent of the world's livestock[4], and sustain the livelihoods of millions of people (25 million in Africa alone) who would otherwise have to make a living outside the rangelands at arguably greater net cost to the environment.

Grazing systems are usually geared to the production of multiple outputs, including meat, milk, blood, hides and skins, dung fuel, transportation, flexible household capital reserves and risk management, although ranching systems are generally geared more narrowly towards meat production. Many of these outputs are untraded and markets fail to capture even their direct use values, let alone the broader environmental benefits. Table 2 summarises the findings of a number of studies comparing returns to ranching (single output systems) and pastoral production (multiple outputs) in Africa, and shows that pastoral production consistently outperforms ranching on a per hectare basis. While pure grazing systems may produce only 9 per cent of world meat and 8 per cent of world milk production (Steinfeld et al.1996), their value in providing multiple direct outputs and additional indirect benefits, such as the preservation of landscape amenity and wildlife biodiversity, justifies continued efforts to specify accurately the nature of livestock-environment interactions within them.

Crop-livestock integration is the main avenue for intensification in more humid and sub-humid regions where external inputs are not available, and can support higher rural populations than grazing systems alone. Integrated crop-livestock systems can be environmentally beneficial, as by-products from one production component (e.g. crop residues, manure) serve as inputs to other components. Livestock play a key role in energy and nutrient cycling, as well as providing a diverse range of outputs (McDowell 1977), and rotations of crops with forage legumes replenishes soil nutrients and reduces soil erosion. Even considering direct use values alone, the estimated contribution of livestock to agricultural GDP in Africa, including manure and draught power, may be as high as 35 per cent (Winrock 1992).

Crop-livestock integration may take place at a range of scales, from a single farm unit to an entire region. 'Mixed farming' usually refers to integration within a single farm unit (Winrock 1992), but it is useful to consider farmer-herder interactions on an intra-regional scale under the same general heading, as such interactions have certain advantages over mixed farming, especially in relation to equity and the efficient use of skilled labour (Bayer and Waters-Bayer 1995). While integrated crop-livestock production is the most prevalent form of livestock production system in much of Asia, in Africa it has usually occurred as a process of factor

[4] IPCC Working Group II WorldWideWeb Home Page: http://www.usgcrp.gov/ipcc/html/chap02.html.

and input substitution, induced largely by population growth (McIntire et al. 1992, Tiffen et al. 1994).

Industrial systems Further intensification generally implies the import of external inputs which can bring to an end the beneficial equilibrium between livestock and the environment. Manure, for example, while of primary importance in integrated crop-livestock systems, can in excessive quantities become a harmful pathogen. Industrial systems tend to be geared to the production of single rather than multiple outputs, and which are usually traded on markets. The fastest growing sector of the global livestock industry is poultry production, which increased by 48% between 1984 and 1994, compared with a 3-6 per cent increase for the principal ruminant animals (see table 1).

The principal focus of this paper is on grazing and integrated crop-livestock systems, since it is in these systems that benefit-sharing between livestock production and the environment is most prevalent and offers most potential for enhancement through policy intervention. Given the space constraint, rather than attempt to give a comprehensive overview the paper will highlight those issues which seem to be most frequently misrepresented and which offer substantial scope for benefit sharing through innovative institutional and policy initiatives. Some successful examples of benefit sharing of environmental goods and services are given as text boxes throughout the paper. In industrial systems the relevant policy options are more a question of damage-limitation or reducing the environmental costs associated with livestock production (Young 1996). These issues fall outside the scope of the present discussion.

ENVIRONMENTAL GOODS AND SERVICES APPROPRIATE FOR BENEFIT SHARING

This section defines the main types of environmental goods and services appropriate for benefit sharing. First we consider those environmental services provided by livestock production which have *ecological function values*, including the maintenance of terrestrial ecosystems (supporting rangeland productivity, nutrient cycling and soil fertility enhancement, and carbon sequestration), and the preservation of wildlife and other forms of biodiversity. Next are those environmental goods and services which yield *direct use values* to society, and which livestock production helps provide. These include landscape amenity, weeding services, draught animal power and livestock-derived energy sources. In the case of draught power and household energy supply from livestock, additional environmental benefits derive from the fact that they carry lower opportunity costs in terms of net greenhouse gas emissions, compared with alternative (fossil-fuel based) means of supplying the same services. Finally, we consider livestock-related environmental goods that have *option values*, especially animal genetic resources.

Ecological function values

Sustainable rangeland management: Conventional wisdom suggests that much of the blame for 'desertification' and land degradation in arid rangelands rests with pastoral livestock production. There is now a considerable literature which corrects this misconception, on two counts: (i) the extent of dryland degradation is greatly exaggerated, because the underlying ecological dynamics have been misunderstood[5] (Behnke et al. 1993, Swift 1996); and (ii) the contributory role of livestock has also been misspecified (e.g. Sandford 1983, Homewood and Rodgers 1987, Behnke 1994). If desertification is understood as irreversible degradation, then a far smaller proportion of arid rangelands are thus affected. Dryland ecosystems are now understood to be:

- highly variable over time, heterogeneous in space, and resilient; in which
- long-run primary productivity is influenced more by abiotic factors such as rainfall than by the density of grazing livestock within the system; and
- the flexibility of opportunistic or 'tracking' strategies of mobile animals, along with many other adaptations herders and farmers make to the vagaries of such dynamic, event-driven ecosystems, allows the exploitation of the varied phenology, production dynamics and forage quality of diverse feed sources.

These factors make possible continued human habitation of 'marginal', variable dryland environments such as the Sahel. They also permit the integration of several production systems on a regional basis, each of which would be unviable on its own, as in the case of the Inland Niger Delta (Moorehead 1991). Therefore, under the right conditions, production systems relying on mobile livestock represent the most sustainable way to utilise arid rangelands (see Box 1), and can and ought to be supported and enhanced through policy intervention designed to give greater decision-making power to local producer groups (Scoones 1995). These issues are addressed in more detail in the sections below.

A wealth of evidence exists to support the view that light or moderate grazing by livestock increases rangeland productivity in many grazing systems. For example, removal of coarse, dead stems permits succulent new shoots in species such as *Themeda triandra* in African savannas. The seeds of some plant species are spread efficiently by being carried in cattle guts, then deposited in dung in favourable seed beds or trampled into the soil. The passage of herbage through the gut and out as faeces modifies the nitrogen cycle, so that grazed pastures tend to be richer in nitrogen than ungrazed ones. The recruitment of tree species is also favoured under certain conditions by grazing animals. Reid and Ellis (1995) found that goats play a key role in enhancing recruitment reliability of the important *Acacia tortilis* tree in South Turkana, Kenya. Similarly, in nature reserves along South Africa's Eastern Cape, recruitment of certain rare tree and shrub species including cycad and the endemic Pondoland palm, which are regarded as an important justification for nature conservation in the area, appears to be favoured in former homestead sites where livestock corrals have concentrated nutrients[6]. Goats have been found to play an important role in the maintenance of Arizona chaparral by reducing brush cover (Severson and Debano 1991), and in controlling the noxious weed leafy spurge throughout the western US, thereby enhancing biodiversity and landscape amenity. Indeed, the removal of grazing pressure owing to forced abandonment of

[5] The science of dryland degradation has in fact been well understood for several decades, such as the fact that large inter-annual shifts in desert margins and in biomass production can be explained by variations in rainfall. Swift (1996) argues that the persistence of the concept of 'desertification' in the face of mounting evidence that it is inaccurate, and the perpetuation of policies which rest on the view that pastoral livestock production is largely to blame, have less to do with science than with the competing claims of different political and bureaucratic constituencies.

[6] Thembela Kepe, personal communication (1996) in connection with research in progress under the 'Environmental Entitlements' project, Institute of Development Studies, UK, and University of the Western Cape, South Africa.

grazing land in areas of endemic armed conflict, such as Turkana district of Kenya and the areas which border it, can itself lead to undesirable landscape changes in the form of dense thorny scrub invasion (Conant 1982, Hendrickson et al. 1996). The potential complementarities between landscape amenity, wildlife biodiversity and grazing livestock production are discussed separately below.

Box 1 The effectiveness of pastoral land management practices: lessons from Central Ferlo, Senegal

From the early 1980s, GTZ experimented with a new method of pastoral resource management around the Widou Thiengoli borehole in Central Ferlo, Senegal. The new management model was based on the principle of sustaining balance between available pasture and stocking rates within a fixed territory, privatised for the purpose of the experiment. The system was monitored continuously for 12 years for its environmental and socio-economic impacts.

The controlled grazing experiment enclosed an area of around 1,500 ha into six 200 ha plots, together with 200 ha set aside for regeneration and 100 ha for livestock routes. Plots were managed according to different, but moderate, stocking densities so as to test several scenarios, and were compared with herds outside the scheme on common grazing land. In order to maintain constant stocking density, control herds inside the scheme were to receive supplements in the event of a fodder deficit.

Several problems emerged from the monitoring studies. First, the period 1981-92 was characterised by extreme variability in rainfall and therefore plant biomass production. The constant stocking density proved to be incompatible with the wide variations in available forage. In bad years, stocking densities were too high and herds had to be moved out to survive. Available forage was insufficient in 3 years but under-utilised in 4 years out of the 12. Only in 2 years did stocking density and carrying capacity actually match up. Second, the impact on grazing resources was more negative than positive, owing to under-utilisation, a decline in quality of pasture, and a thinning out of drought-resistant fodder species. Controlled grazing also failed significantly to improve ligneous vegetation cover. Third, while animal production effects were good in good years, animal vulnerability increased in bad years. For a range of socio-economic reasons as well, it was concluded by GTZ that controlled grazing under these conditions was unviable.

Comparisons with pastoral management practices outside the scheme revealed the superiority of the latter, owing to the inherent limitations of the concept of carrying capacity in an environment not at equilibrium; the difficulties of applying a closed model of water and grazing management on a large scale; the reduction in animal mobility and flexibility which resulted; and the removal of the positive, symbiotic interaction of animals and plant communities. GTZ concluded that efforts to support pastoralists' self-reliance would have to depend much more on the creation of a favourable institutional environment, including securing pastoral land rights and access to fall-back areas.

Source: Thébaud, Grell and Miehe (1995)

<u>Preservation of wildlife biodiversity</u> The relationships between wild and domestic ungulates co-existing in the same habitats are complex, and turn on the questions of the extent of dietary overlap and competition for forage, and of disease vectors. For example, domestic sheep are acknowledged to be carriers of disease which threaten populations of wild Bighorn sheep in western USA. But these relationships are by no means always competitive. Many recent studies point to the potential for complementarity and even symbiosis between wild and domestic ungulates, especially in relation to foraging patterns. Domestic as well as wild ungulates are an integral component of co-evolved dryland ecosystems many regions of the world (e.g. Homewood and Rodgers (1987) and Little (1996) for East Africa; Hoffman et al. (1996) for the South African karoo; Perevolotsky (1995) for the Negev, Israel; Sheehy (1995) for Mongolia and China; and West (1993), Sheehy and Vavra (1995), and Hobbs et al. (1996) for western USA, to cite but a few studies). Failure to recognise these potential

complementarities has led to missed policy opportunities for achieving benefit sharing between livestock and environment (see Box 2). The presumption that livestock are necessarily inimical to the conservation of wildlife biodiversity has led to policies favouring wildlife over pastoralists, with consequences that perversely harm the environment as well as livestock producers and national economies (McCabe et al. 1992, Norton-Griffiths and Southey 1995).

The state-of-science in biodiversity conservation is now shifting from protection for 'charismatic' species to defensively managing larger tracts of land with habitats or ecosystems holding suites of sensitive species (West 1993, Perrings et al. 1995). It is increasingly acknowledged that moderate livestock grazing will actually increase the chances of survival of some species, and can enhance community- and landscape-level diversity in many instances (West 1993).

Box 2 Complementarity of wild and domestic herbivores in environments of high amenity value

In western USA, demographic and political forces increasingly favour recreational uses over livestock production in landscapes of high amenity value, owing to the relatively greater lobbying strength of an increasingly urbanised electorate. But these demographics are not shared in much of the developing world, and here the distribution of environmental costs and benefits takes on a North-South dimension.

It has been argued that the current antipathy between livestock producers and environmental lobbying groups in western USA has led to missed opportunities in forging alliances against uncontrolled residential and urban development which has far worse environmental impacts than even the worst excesses of livestock production. The adversarial relationship between livestock producers and environmentalists in the US has a disproportionate effect in other parts of the world as well. Development policy options in places as far afield as Mongolia are being unnecessarily restricted, based on the misconception that relations between wild and domestic herbivores are invariably competitive.

Recent research in northeastern Oregon, however, shows that cattle grazing improves the quality of seasonal rangeland forage available to elk during critical periods of nutritional stress. The removal of cattle from publicly managed seasonal rangeland in response to concerns over endangered wildlife species may in fact cause elk to concentrate foraging activities on whatever seasonal rangeland continues to be grazed by cattle: namely, privately owned land which often contains stream and riparian habitat important to valued species of fish and wildlife such as the Chinook and Snake River salmon. Similar findings regarding the potential complementarity and even symbiosis of wild and domestic herbivores have been made for North American sagebrush grasslands, and for similar environments in Mongolia.

Sources: Daniels (1996), Sheehy (1995), Sheehy and Vavra (1995), Hobbs et al. (1996), Huntsinger and Hopkinson (1996), Jackson (1992)

<u>Soil fertility enhancement/ nutrient cycling</u> In integrated crop-livestock systems, benefits are shared between livestock production and other uses of the environment in terms of soil fertility enhancement and nutrient cycling, whether on-farm, intra-village, or intra-region (Bayer and Waters-Bayer 1995). Pastures and fodder fields suffer less soil erosion and absorb more water than row-crop fields, and leguminous fodder plants such as alfalfa also improve soil fertility. Manure from livestock (pigs and ruminants together) may contribute as much as 35 per cent of soil organic matter (Steinfeld et al. 1996), helps maintain soil structure, water retention and drainage capacity. The value of manure is so well recognised that many farmers keep livestock primarily for this purpose. Feeding crop residues to livestock is also the best way to utilise 'waste' products, as nutrient uptake is achieved more efficiently than if stalks were added directly to the soil, and burning would increase CO_2 emissions.

With growing population densities, farmers in semi-arid areas such as the Sahelian and Sudanian belts of West Africa face rising transaction costs in obtaining manure (Toulmin 1992). This raises the question, why not move to mixed farming rather than rely on feed-manure exchanges between farmers and herders, and thereby internalise those transaction costs? Bayer and Waters-Bayer (1995) suggest that one reason farmer-herder exchanges continue to be preferred is on grounds of equity and efficiency in the use of skilled labour; this finding is supported by Delgado (1978) on grounds of the high opportunity cost of seasonal labour in farming.

While crop-livestock interaction can at best maintain nutrient balance, positive trends are also possible, including shifting from cattle to sheep and goats, and introducing stall feeding, which significantly increases the amount of nutrients available from manure (see Box 3). The cultivation of legume fodders and trees, for example, in alley farming systems, also contributes to soil enrichment through nitrogen fixation (see Box 4). In Colombia and Vietnam, where sugar cane is used as livestock feed, it has been shown that the recycling of dead leaves into the soil, instead of burning them, favours nitrogen fixation by bacteria and reduces weed growth, thus increasing crop yields (Sansoucy 1995).

Box 3 Introduction of stall feeding of livestock in watershed management projects, Rajasthan, India

In the Aravalli Hills of Udaipur district, southeastern Rajasthan, a wide variety of watershed management projects have been introduced by governmental and non-governmental agencies in order to improve ground vegetation cover, improve soil and moisture conservation, and improve farming livelihoods. Livestock play an important role in local production systems, particularly as a source of organic fertiliser, for draught power, and for milk. A few cattle or buffaloes and small ruminants are kept by farmers of most castes, including oxen if they are better-off, but larger herds of goats and sheep, and camels, are kept by scheduled castes and tribes such as Gairi, Rebari, and Dangi. Some of the watershed development projects have enclosed areas of common grazing on hillsides, and have treated the enclosed areas with soil and water conservation bunds, tree planting, live fencing, and maintain social controls to keep livestock out. Very little common grazing remains.

Stall-feeding of animals has become commonplace, and for most families with relatively few livestock, cutting and carrying fodder from their own fields, those of others, or from the enclosures (which are opened for this purpose on a few days each year), is sufficient to meet livestock feed requirements. These farmers carry manure to their fields, and mix it with crop residues and household wastes in compost heaps before applying it to the soil. They claim crop yields have increased significantly following the introduction of these techniques. Those who rely relatively more on livestock have lost out however. They can graze their animals only along roadsides or on the few the degraded areas of still common access grazing land. Manure-for-feed exchanges are so far only in their infancy, but may provide promise for the future for the livestock keepers.

Box 4 Agroforestry options agropastoral and dairy production

In the agropastoral area of Konso, southern Ethiopia, a tree-planting programme began with Norwegian support in the late 1970s with the aim of reducing soil erosion and providing building poles and fuelwood. These were not the felt needs of local people, however, and the project shifted its focus towards trees that could provide fodder for livestock. While conflicts over grazing were common initially, in time, local communities proposed more suitable planting sites and took initiatives to protect tree seedlings from grazing livestock. They also began to plant *Terminalis brownii*, an indigenous agroforestry species which coppices easily, and the leaves of which provide valuable fodder, especially for stall-fed sheep.

In Kilifi district on the Kenyan coast, a local energy research station developed an alley-cropping package as a solution to the problem of low and declining soil fertility, comprising leguminous trees grown in parallel lines with food crops. On leaving the research station, local farmers modified the package substantially as the *Leucaena* trees were valued far more as a source of animal fodder. Farmers felt benefits in terms of higher cash incomes from the sale of milk, and higher crop yields from the application of manure. Leucaena fodder significantly helped to bridge the dry-season fodder deficit.

Source: Leach and Mearns (1988)

Carbon sequestration It is very difficult to make generalisations about the role of livestock production systems in contributing to global warming via carbon emissions. While livestock grazing is responsible for removing herbaceaous and woody biomass, an inverse relationship is also commonly observed between the extent and frequency of fires and livestock density. That is, greater livestock density reduces biomass removal by fires, thereby increasing available herbage and reducing relative removal rates by livestock (de Leeuw and Reid 1995). For all of Africa in 1993, land use change resulted in an estimated 730 million tonnes of CO_2 emissions, of which only 9 million tonnes net, or just over 1 per cent, was contributed by livestock production (World Bank African Development Indicators, 1996, Table 14.15).

Although the relationships are complex are difficult to generalise, many micro-studies, such as one in the Netherlands (Vandasselaarn and Lantinga 1995), show higher soil carbon fixation under livestock grazing by comparison with other management regimes. The terrestrial stock of carbon, however, is highly uncertain, and has been hypothesised as a possible site for a 'missing' carbon sink, in which the maintenance of savanna ecosystems may play an especially important role. What is known however, is that various technological options do exist for inducing incentive-compatible forms of land use change under livestock production, as ways to achieve higher standing biomass cover and therefore net carbon storage. These options include efforts to slow rates of land clearance for agriculture, and to increase production of perennial fodder crops and trees in farming systems (G. Leach and Mearns 1988, Swallow 1995).

Direct use values

Landscape amenity Many of the world's highly valued grassland landscapes, e.g. North American prairies, Argentinian pampas, East African savannas, Mongolian steppes, and alpine meadows, have long been grazed by domesticated as well as wild herbivores. Cattle, sheep, goats and other ungulates appear to have been first domesticated around 9,000 to 11,000 years ago, and 6,000 to 8,000 years ago people began taking herds onto savanna landscapes in Africa (Lamprey 1983, cited in Young and Solbrig 1992: 15). They are co-evolved landscapes, and grazing livestock play an integral role in their maintenance (West 1993). They are also anthropogenic landscapes (Spooner and Mann 1982, Adams and

McShane 1992, Leach and Mearns 1996), and many people place both direct use and option values on their preservation, including such human artifacts linked to livestock production as dry-stone walls in the British Pennines and traditional hay stooks in the Austrian Tyrol. Within Europe, benefit sharing mechanisms have been addressed explicitly, and income support payments are made to farmers in the interests of landscape preservation. Payments are made through the European Community, for example, to compensate farmers in designated Environmentally Sensitive (or Stewardship) Areas for grazing extensification with the aim of restoring vegetation species diversity (cf. Bullock 1996). In southern England, public nature trusts themselves own flocks of sheep used in the management of chalk downlands, as selective grazing is the only known way to maintain vegetation species richness in these fragile landscapes.

Draught animal power Some 52 per cent of the cultivated area in developing countries (excluding China) is farmed using only draught animals. Compared with the use of tractors, animal power is a renewable energy source, is produced on-farm with almost all of the required implements made locally, with far lower opportunity costs in terms of greenhouse gas emissions from fossil-fuel burning, and with additional environmental benefits of nutrient cycling (Sansoucy 1995, Singh et al. 1995). It has also been argued that animal traction can have positive gender impacts (Hofs et al. 1993). Unlike in much of Asia, efforts to introduce animal traction in Africa have been disappointing, given the relative opportunity costs to farmers of land, labour and capital (McIntire et al 1992). Even in many parts of Africa, however, the conditions for adoption of animal traction, including rising population density and introduction of high value-added cash crops and market accessibility, have been present (Delgado 1989, Tiffen et al. 1994), and that even the high initial capital investment costs (Panin and de Haen 1989) can be overcome.

Household energy supply In many countries, animal dung is a preferred cooking fuel, either year-round, seasonally, or for particular types of cooking. It is the major source of household energy for millions of people in Asia, Africa, parts of the Near East and Latin America. It is often argued that burning dung as fuel carries a very high opportunity cost in terms of 'lost' soil nutrients. One study using replacement cost valuation techniques, for example, estimated this opportunity cost to be as much as 9 per cent of Ethiopia's GNP in 1983 (Newcombe 1989, cited in Pearce and Warford 1993: 25). This is almost certainly a gross exaggeration, based on the fallacy that using dung as fuel is necessarily diversionary. As other studies show, however, the use of dung as fuel is rarely a recent phenomenon, and may always have been practised in particular localities without any 'diversion' of soil nutrients (G. Leach and Mearns 1988). Indeed, the case is usually made in order to justify large-scale afforestation projects, which frequently carry heavy costs in terms of lost grazing for livestock.

Biogas production from animal manure has also been successfully adopted by millions of farmers in developing countries as a source of household energy substituting for fossil fuel or fuelwood. About 25 million people use it in China alone (Sansoucy 1995). Effluent from biodigesters can also be recycled as fertiliser, with even better results than the original manure, or as fish feed in aquaculture systems, and can provide additional services such as lighting, warm water, water-pumping and heating. All of these applications substitute for energy sources with arguably higher environmental costs in terms of greenhouse gas emissions.

Weeding services Livestock, especially sheep, are also efficient in controlling weeds, with environmental benefits in terms of landscape amenity value and biodiversity as well as economic benefits in higher crop yields. Sheep weeded American corn fields before the Second World War, for example, and ducks and geese still control weeds on Southeast Asian farms (Baker et al. 1990). Livestock graze beneath trees in rubber and oil-palm plantations in Malaysia, and increase overall production while reducing the cost of weed control (using less environmentally methods) by up to 40 per cent (Sansoucy 1995). It is common to use livestock grazing as a means to reduce fire hazards in forests, or accidental burning at an inappropriate time in burning management regimes for livestock production in areas as diverse as those in the Mediterranean, British moorlands, and South Africa.

Option values

Animal genetic resources The four principal mammalian livestock species (cattle, sheep, goats, pigs) have diversified under more than 5,000 years of domestication and artificial selection into more than 2,000 recognised breeds, each with unique characteristics (see table 1). Intensification of production has gone hand in hand with a narrowing of the genetic base, especially among cattle and pigs. But it is now recognised that the pool of genetic resources represented by domestic animal diversity is an essential basis for global food security, and is likely to be of increasing importance in more demanding production environments.

Traditional breeding practices tend to select for survival under conditions of stress such as extreme cold and seasonal feed deficits (see e.g. FAO 1991 for the Mongolia case), unlike conventional breeding which selects for meat or milk productivity under controlled, high-input conditions. In arid, drought-prone rangelands, low-input animals such as zebu cattle are physiological adapted to 'track' available feed and water supply by shifting their metabolic rate by season and between years, thus permitting optimum exploitation of highly variable environments (Western and Finch 1986, Bayer and Waters-Bayer 1995). However, attempts to introduce high-productivity, exotic breeds into low-input, high-stress environments has often been to the detriment of locally adapted and highly variable animal genetic resources - precisely the qualities required to further develop and sustain production in otherwise inhospitable environments. FAO conservatively suggests that one in four breeds is now threatened with extinction (Hammond and Leitch 1995).

This section has reviewed the environmental goods and services appropriate for benefit sharing between livestock production and other legitimate resource claimants, including future generations whose preferences cannot yet be known. It is clear that livestock can, under the right conditions, be good for the environment. But not all of these benefits can be maximised all of the time for all users. The environment in grazing and crop-livestock production systems is above all characterised by multiple uses and multiple users. This poses significant analytical challenges, but advances have been made recently in understanding how better to account for benefit-sharing, and how to translate analytical insights into policy recommendations, as the following section discusses.

INSTRUMENTS AND MECHANISMS OF BENEFIT SHARING

This section addresses the institutional instruments and mechanisms for bringing about benefit-sharing, with a particular focus on co-management, and decentralisation of decision-making according to the principle of 'subsidiarity', or ensuring that management decisions are taken by the appropriate stakeholders at the appropriate scale level. The discussion necessarily touches on issues of local participation in benefit sharing, including the specification of benefits to be shared, equity, the role of government, and the advantages and disadvantages of decentralisation.

The general underlying argument here is, first, since livestock production already yields many significant environmental benefits under certain conditions, institutional and policy frameworks need reform to give due recognition to those benefits, and allow livestock producers to deliver them unhindered. Various mechanisms are possible for internalising environmental externalities besides efforts to extend the market, including facilitating collective action among user groups. Second, where changes in livestock production systems are required to enhance their potential positive contribution to the environment, or to reduce their negative impacts, the policy process should be concerned not just with *what* technical options should be applied, but also with *how* technical and institutional reforms are brought about.

Benefit-sharing among local users

Livestock under grazing and many crop-livestock systems are produced within multiple-use common property regimes. Insights from the theory of common property regimes tell us that under the right conditions, collective action among users can internalise environmental externalities. Consider the 'primary' function of common property regimes: allocation of a stream of benefits among multiple users. Customary rationing mechanisms exist in many pastoral production systems to limit off-take and ensure sustainability, but they are usually not a question of limiting animal or human numbers, as is often assumed (Swallow 1996). Instead, rationing takes such forms as rules of entry to or exit from the regime as a whole, often determined by social norms and codes of conduct; rules governing the use of water points; opening and closing dates for particular pastures; and rules regarding sound pasture use (e.g. Mearns 1993, 1996a for Mongolia). Similarly, in Lesotho, the *maboella* regime governing the use of common land around villages for grazing, collection of dung, thatching grass, wild vegetables and medicinal plants by multiple users, has been developed endogenously to protect trees and other forms of plant cover (Swallow 1996). Such forms of collective action require extensive and detailed local knowledge.

Common property regimes also provide a range of 'secondary' functions besides allocation, including risk management, livelihood security, and the exploitation of economies of scale and scope in production and collective action (Swallow 1996). In many grazing systems, cooperative herding arrangements make most efficient use of labour by exploiting economies of scale in production. Similarly, in crop-livestock systems, integration of livestock and crop production, rather than simply interaction between the two, exploits economies of scope in production: it is more efficient to perform them both together[7].

[7] See Bayer and Waters-Bayer (1995) and Delgado (1978) for opposing arguments in favour of farmer-herder interaction owing to other labour-related transaction and opportunity costs.

Recent research also suggests that there are economies of scope to be gained from collective action, even where allocation of benefits to livestock production may not be considered the 'primary' function of the regime (White and Runge 1995, Mearns 1996a). That is, limiting off-take of conditionally renewable resources may only be one of a number of objects of collective action. Others may include, for example, processing and marketing of livestock products, or a wide range of social and ritual activities. Cooperation across a range of activities exploits economies of scope in collective action, since a minimum basis of 'social capital' is required for each to be successful, including trust, and the capacity for endogenous rule-making and enforcement (Swallow and Bromley 1994). Put simply, the 'social capital' required for the sustainable and productive management of dynamic and risky environments would be undermined if it were not for cooperation in livestock production as well as in other spheres of economic and social life[8].

Co-management: benefit-sharing between local and other resource claimants

It is now widely suggested that the theoretical and practical benefits of collective action at the local level to achieve balance between livestock production and environment can best be captured within co-management regimes (Swallow and Bromley 1994, Western et al. 1994, Baland and Platteau 1996). Such regimes aim to forge an effective partnership between the state and its constituent stakeholders, and the wide variety of potential users of environments used for livestock production. The state carries overall responsibility for arbitrating conflicting interests at the national level, and facilitating negotiation between these multiple stakeholders. But the theoretical arguments above suggest that many practical management decisions and negotiations among competing users will need to be made at a local level, since they rely strongly on indigenous knowledge, flexibility in the face of variable and contingent conditions, and interaction within small groups within which repeated interaction builds social capital.

Swift (1995) argues for the adoption of the principle of 'subsidiarity' in the administration of grazing systems: that some administrative powers currently held by government, and which duplicate or undermine those governance structures evolved at local level, could be delegated to local groups, thus lightening the burden on government and leading to more efficient administration and substantial cost-savings. The delegation of powers to local level would aim particularly to:

- strengthen customary resource rights (Lane and Moorehead 1995), such as the *xeer* system of customary law in Somalia (Said Samantar 1994), or the *maboella* regime in Lesotho (Swallow 1991); (see also Box 5 for the case of pasture land leases in Mongolia)

- define a clearer set of procedural tasks for formal law, such as defining the boundaries within which customary law takes precedence, and providing formal reconciliation and conflict resolution mechanisms to arbitrate between contested claimants (Swift 1995)

[8] It has been argued elsewhere that success in land reforms in areas of extensive livestock production in post-Soviet Central Asia is being hindered by a lack of 'social capital', or relations of trust and reciprocity among stakeholders (Mearns 1996b).

- avoid specifying the actual content of land tenure policy, since the latter would require the enforcement of fixed territorial boundaries while the necessary degree of flexibility in the face of risk and uncertainty would require them to be 'fuzzy' (Behnke 1994)

- compensate for regime failure with respect to benefit-sharing by means of facilitating the formation of coalitions or federations of pastoral and other groups (Wilson and Thompson 1993). Different functions of multiple use common property regimes have different implications for group size as well as boundary definition (Swallow 1996, Baland and Platteau 1996). For example, while the allocation function requires group size to be as small as economically and technically feasible for the number of resources, uses and users in question (with preferably fixed boundaries), the risk management function requires group size to vary from small to large, depending on the level of environmental co-variation across the landscape (with preferably flexible or 'fuzzy' boundaries).

Box 5 Pasture land leasing in Mongolia

Since 1991 Mongolia has made the transition from a centrally planned to a market-oriented economy. Among the sweeping legislative reforms is a new land law, which contains various provisions that could stand to benefit pastoral livestock keepers substantially. Almost half of the Mongolian population are livestock herders, and livestock production is by far the major form of land use and agricultural output. Livestock and land management strategies are shaped first by the physical and biological constraints of the varied steppe, mountain and desert environments throughout the country, which are largely non-equilibrial in character; and second by the institutional frameworks arising from the interaction between the central political regime of the moment, and the customary institutions of herders themselves.

The new land law allows for land leases of up to 60 years to be issued to groups or to individual herders. These leases are likely to be taken up for those pastures over which there are more clearly alienable rights, such as winter pastures and hayfields. Most land will continue to be allocated by local administrations. However, a significant degree of de facto 'co-management' already takes place, as local managers broadly recognise the rationality of herders' own knowledge and validity of their customary resource claims. The land law specifically recommends that grazing should follow traditional seasonal movements between pastures, and provides emergency reserve pastures. The land leases could potentially build on customary institutions based in cooperative herd and labour management at camp and neighbourhood levels. Decision making is explicitly moving downwards to the local level, and away from centralised bureaucracies as it was under collectivisation.

The apparent continuities of customary institutions may be deceptive however. Widening income disparities in rural areas, combined with recent migration of people from towns into rural communities to take up herding but often without the requisite skills, is leading to an erosion of social capital within herding communities on which collective action in pasture management depends. The greater tenure security offered by the new land leasing arrangements may be the best hope for resolving these conflicts in the future.

Sources: Mearns (1993), PALD (1993), Mearns and Swift (1996)

For co-management arrangements to be successful in arbitrating among contested resource claims, it is clearly necessary that the full range of potential users be recognised or anticipated. For example, careful attention to achieving subsidiarity in the interests of pastoral administration will be of little use if pastoralists' land claims are superseded by those of wildlife tourists rather than both being given credence and legitimacy by government. There are perhaps more documented examples of wildlife being given precedence over pastoralists than vice versa (e.g. Norton-Griffiths and Southey 1995, McCabe et al. 1992, Brockington and Homewood 1996), but opportunities are widely perceived to exist to achieve better balance between the two.

A major challenge in identifying the share of benefits to be distributed benefit-sharing mechanisms of this sort is that different users of a given environment may have fundamentally different views about the relative values of different outputs, about the appropriate role and number of livestock, and about what the environment should look like. These issues are inherently value-laden, and cannot be defined objectively. Some views are bound to have more powerful adherents than others. What can be done through careful research, however, is to specify a range of scenarios with various combinations of outputs, from careful analysis of, for example, wildlife-livestock interactions. Each of these scenarios will necessarily be culturally constructed, and will be undergirded by quite different power relations, but making them explicit must be the starting point for negotiation over their relative merits and demerits. This task, however, implies a fundamental shift in the relationship between research and the policy process.

Integrated Conservation and Development Projects

A now common form of co-management for benefit-sharing between livestock production and the preservation of wildlife biodiversity is the notion of integrated conservation and development projects, or ICDPs (Wells and Brandon 1992, Wells 1995, Western et al.1994). All such projects rest to a greater or lesser extent on the following principles:

- **indigenous knowledge** is essential for biodiversity conservation (for example, to protect particular biological communities (e.g. vulnerable wetlands), to protect all individuals of certain species (e.g. particular fodder tree species), to protect organisms at vulnerable stages of their lifecycle, and to carry out periodic harvesting as a group activity so as to monitor populations and harvesting levels effectively)

- **local participation.** Despite much rhetoric to the contrary, most ICDPs to date have treated local people as passive beneficiaries of project activities rather than empowering people to mobilise their own capacities and control the activities that affect their lives (IIED 1994, Wells 1995, Pimbert and Pretty 1995). Appropriate approaches for effective participatory inquiry and planning are now well developed, drawing on many long-established traditions (Chambers 1996, Pretty 1995), and imply a radical departure from current practice for most development professionals, but they have yet to be applied on a wide and meaningful scale in operational ICDPs. There is much scope for improvement on current best practice.

People can only be empowered in aspects of development, including local natural resource management to meet livelihood entitlements, that do not lead to over-exploitation or degradation of the protected biodiversity. In practice, this is very difficult to achieve using economic incentives alone. Project-based approaches have inherent limitations that are often overlooked. Factors leading to loss of biodiversity include public ownership of extensive ownership of extensive tracts of land, unmatched by government capacity to manage that land effectively; powerful financial incentives encouraging resource mining; and laws, policies, and economic trends over which isolated rural communities have no influence (Wells 1995). The 'subsidiarity' or co-management approach rests on adoption as national-level policy, as it requires the possibility of change in the institutional and policy environment. This is option is not possible at the level of individual, often short-term, pilot projects (cf. Toulmin 1991).

Rather than adopt a project-based approach to balancing environmental and livestock benefits from the environment, many developing countries have adopted policies to encourage ecotourism. However, limited success has so far been achieved in this regard, owing to:

- lack of analysis of the real economic potential of ecotourism
- failure to capture a greater proportion of ecotourism's benefits locally and nationally (cf. Norton-Griffiths and Southey 1995)
- failure to regulate visitor's adverse environmental and cultural impacts, arising from the often false perception that total numbers of visitors will yield greater revenues than efforts to increase fees and charges from a smaller number of visitors (Lindberg 1991)
- failure to provide additional funds for biodiversity conservation

Pastoral associations

The principles of subsidiarity reviewed above imply new roles for pastoral associations. Following the dismal peformance of ranching and range livestock projects between the 1960s and the 1980s, the World Bank shifted attention in the 1980s towards pastoral institution-building (Shanmugaratnam et al. 1992). While these projects were based on broader premises such as integrated natural resource management, the enabling role of policy and institutional reforms, and the importance of local participation, they still largely failed to facilitate a genuinely participatory process of self-development, embedded as they were in the authoritarian cultures of governments and project administrations (Vedeld, in de Haan 1994). They still relied heavily on the notion of spatial delineation of rangeland territories, even though customary land rights were given legal recognition as the subsidiarity principle suggests.

The implications for future pastoral development initiatives follow from those given above in relation to subsidiarity: focus attention on procedural law and longer-term political processes, and the resolution of conflicts, civil security and drought preparedness, rather than attempt to specify in detail what tenure rights should prevail over what resources. The implications for groups and for institution-building are to accept that groups of various sizes are likely to federate together for certain purposes, while separating for others. In all cases, however, the importance of developing long-term relationships, and beginning from local priorities and understandings, is paramount.

Financial instruments, public subsidies and investments

<u>Beneficiary-compensation payments</u> At the international level, the only operational programme through which contributions could be made to livestock producers to finance the incremental costs of biodiversity conservation and protection of landscape amenity in developing countries is the Global Environmental Facility (GEF). The European Union already operates a similar financial mechanism for achieving benefit-sharing between farmers and the environment. Although as Norton-Griffiths and Southey (1995) note, the GEF was not designed with situations such as the one described here in mind, there is no reason in principle why it could not be used to finance such activities, provided a reasoned case could be made for the advantages of recognising and further developing the role of livestock

producer groups in biodiversity conservation. There is a need for further research in this respect, to specify clearly the nature of interactions between livestock produced under existing conditions in areas of high amenity or conservation value, to identify the range of options available for ensuring the most beneficial forms of benefit-sharing, and to provide costed proposals for any new incremental activities to be undertaken by livestock producers.

Taxation Livestock production in variable environments should not be taxed as though it had a stable and regular set of outputs. Taxation systems currently in use tend to have perverse environmental and equity implications for benefit-sharing of environmental goods and services. Head taxes on animals, for example, common in West Africa, would be fair and efficient if applied progressively (i.e. higher head tax on larger herd sizes), but this rarely happens and would be costly to collect. Sales taxes may disproportionately affect small herders who usually sell a larger proportion of their animals, and would be especially burdensome in drought years when all herders well more animals (Swift 1995). Grazing fees discriminate against small herders. The important thing in dynamic environments is that whatever taxation system is chosen, it is applied flexibly, and that a moratorium on taxation is declared in the event of drought. Efforts to specify more comprehensively the total economic value of livestock production should provide a sound basis on which to reinvest tax revenues in livestock production systems, and could form an additional source of revenue for financing the incremental costs of establishing effective co-management arrangements.

Other instruments are discussed in the literature as means to enable pastoralists and other livestock producers to cope better with environmental risk and uncertainty, including insurance and credit (Swift 1995), measures for rapid destocking and restocking, according to particular phases in the drought cycle (Toulmin 1995), and investments in marketing, transport and communications infrastructure to facilitate rapid off-take when necessary (Holtzman and Kulibaba 1995). All such measures would help support the conservation potential of dryland grazing systems. Rapid destocking (at supported prices) during the onset of drought, for example, would help protect forage for wildlife in the short term.

CONCLUSIONS AND RECOMMENDATIONS

The following recommendations are among those of highest priority for inclusion in action plans and pilot activities, to accentuate the positive in livestock-environment interactions, and to build on new understanding and the limited successes achieved to date. First, two cross-cutting themes or general principles are reviewed. These are followed by a summary of the kinds of instruments and mechanisms recommended for bringing about closer benefit-sharing of particular environmental goods and services.

Inform decision-making

The 'new' thinking in range ecology suggests an urgent need for training of a new generation of range managers able to combine technical insight with socio-economic analysis. They need to have the ability to focus of the needs of multiple, competing users; facilitate participatory planning processes; and negotiate during conflicts, among many other technical skills (Scoones 1996). For example, the quest for a simple carrying capacity number is inadequate for non-equilibrium, or even intermittent equilibrium, rangelands. A more sophisticated approach based on risk analysis for forage demand and supply is required, but one which does not aim to produce a rigid scientific assessment appropriate for all producers for all time (*ibid.*), but instead accepts that stocking strategies and management practices will vary according to a multiplicity of desired outputs and environmental/ amenity services. While vested interests and powerful constituencies will continue to oppose change, the persistence of outmoded concepts and ways of working are likely to frustrate attempts to balance livestock production and environmental goods and services unless training curricula are radically altered in agricultural colleges and universities throughout the world (cf. Leach and Mearns 1996).

'Democratise expertise'

Many of the instruments and mechanisms for achieving benefit sharing of environmental goods and services discussed in this paper call for new forms of professionalism among government officials and others responsible for implementing policies, programmes and projects (cf. Chambers 1996, Pimbert and Pretty 1995). There is a fundamental need to re-cast the relationship between 'research' and 'policy-making', in order to make explicit the 'plural rationalities' of all stakeholders (Thompson 1993, Leach and Mearns 1996). Much is now known about how to facilitate a genuinely participatory development process, but this urgently needs operational application.

These two general principles underlie all of the technical and institutional options for bringing about benefit sharing of environmental goods and services between livestock producers and other resource claimants. Where changes are required to enhance the potential positive contribution of livestock to the environment, or to reduce their negative impacts, the policy process should be less concerned with *what* technical options should be applied than with *how* technical and institutional reforms should be brought about.

Table 3 summarises the recommendations made in this paper for bringing about closer benefit-sharing of environmental goods and services in livestock production. Following the analytical frame adopted in section 1, this distinguishes the environmental goods and services provided under various forms of livestock production by the nature of their contribution to total economic value: ecological function values, direct use values, and option values. Six potential types of mechanism for bringing about closer benefit-sharing are considered: benefit-sharing among local users (facilitating collective action); benefit-sharing between local and other users (co-management mechanisms, or 'subsidiarity'); beneficiary-compensation payments; taxation; infrastructure development; and technology options. Some examples of specific instruments or mechanisms are described below, following this typology.

Benefit-sharing among local users: facilitating collective action

- at the local level, mechanisms are required for negotiating and resolving conflicts between competing resource claimants. These should focus on procedural law, rather than specifying in normative terms who ought to have access to what resources and when. Such mechanisms will enhance the potential role of mobile livestock production in **sustaining rangelands**. They are also likely to enhance the potential for **carbon sequestration** under livestock production, to the extent that conflicts between farmers and herders may be resolved; and for bringing about effective **nutrient cycling**, for example by means of manuring contracts between farmers and herders. At an operational level, this means understanding in detail the multiple functions of institutional arrangements facilitating land management

Benefit-sharing between local and other resource claimants: co-management or 'subsidiarity'

- many contested resource claims cannot be resolved at the local level but need to be addressed at a higher level of administration. Co-management is limited in its potential if it addressed only through projects. Rather, it needs to focus on policy mechanisms such as secure yet flexible land rights for pastoralists for **sustaining rangelands**. Other means to empower pastoral and other institutions can only be devised with a detailed understanding of the multiple functions of such institutions. **Preservation of wildlife** and other forms of biodiversity will only be achieved if transfers are made between those who benefit from conservation and improved **landscape amenity** at national and international levels, and livestock producers in situ. Such transfers may take the form of **beneficiary-compensation payments** (e.g. compensating livestock producers for income forgone through extensification).

- other examples of beneficiary-compensation payments that build on principles of co-management could include subsidies from CGIAR and other international organisations working to develop **animal genetic resources**, to national research institutions in developing countries that are developing breeds well-adapted to low-resource environments but which do not currently receive international credit for doing so.

Taxation and infrastructure

- instruments of taxation can also help in **sustaining rangeland management** and in **preserving wildlife** and other forms of biodiversity if they reward livestock producers for maintaining moderate rather than high stocking rates. Graduated head taxes are one such form of progressive taxation. Infrastructure development can support such objectives, for example in facilitating rapid offtake of animals at supported prices during the onset of drought in dryland environments. Specific measures should address development of communications to inform producers of likely changes in rainfall and livestock prices; and transport and marketing infrastructure to help them sell animals quickly. All such measures contribute to maintaining stocking levels appropriate to prevailing conditions of forage availability.

Technologies to enhance natural resources

- various technology options are known for enhancing natural resources in low-resource areas in ways that increase biomass cover, and hence contribute to **nutrient cycling**, **carbon sequestration**, and **household energy supply**. These need to be encouraged in ways compatible with the livelihood ans risk-management concerns of livestock producers. Such options include deferred grazing schemes, planting of perennial fodder crops, introduction of stall feeding, and better integration of trees and shrubs into farming systems.

Table 1. World livestock totals and species diversity

Animal	Total number 1994 ('000)	Change since 1982-84 (%)	Total number of known domestic species	Number of known breeds
cattle & yak	1,288,124	3	4	783
sheep	1,086,661	6	6	863
pigs	869,872	12	10	263
goats	609,488	6	9	313
buffalo	148,798	13	4	62
equines	116,882	5	9	435
camelids	18,831	13	2	n.a.
chickens	12,002,000	48	n.a.	n.a.

Sources: For livestock production totals, *FAO Agricultural Production Yearbook* (1994); for information on species diversity, World Conservation Monitoring Centre (1994), *Biodiversity Data Sourcebook*

Table 2. Comparisons between ranching and pastoral production systems in Africa

Country	Comments	Sources
Zimbabwe	All studies show that the value of communal area (CA) cattle production far exceeds returns from ranching. If actual stocking rates are used, CA returns are ten times higher per hectare.	Danckwerts (1974) Jackson (1989) Barrett (1992) Scoones (1992a)
Botswana	Communal area production (in cash, energy and protein terms) per hectare exceeds by at least three times per hectare returns from ranches, even though technical production parameters are lower. The difference in soil erosion levels between the two production systems is negligible, despite differences in stocking rate.	Rennie *et al.* (1977) Carl Bro (1982) Hubbard (1982) De Ridder and Wagenaar (1984) Abel (1993)
Mozambique	Traditional systems have higher overall returns per hectare because of the multiple benefits of draft, transport, manure, milk and meat compared to the single beef output from ranches.	Rocha *et al*. (1991)
South Africa	Cattle production systems in the Transkei show higher returns per hectare, but lower productivity indicators, compared to ranches in the commercial white farming sector.	Tapson (1991, 1993) Richardson (1992)
Kenya	Gross output levels in individual ranches and undeveloped group ranches are comparable. Similarly high levels of productivity were found among livestock in Sukumaland.	De Leeuw *et al*. (1984) Bekure *et al.* (1991) Western (1982)
Tanzania	The productivity of pastoral herds in the Ngorongoro Conservation Area were found to be comparable to commercial herds. The patterns of productivity were similar to those found in Kenyan Maasai herds. Maasai multi-product outputs are higher than ranches on a per hectare basis.	Birley (1982) Homewood and Rodgers (1991) Homewood (1992)
Uganda	Recalculations of figures to include full range of costs and benefits show that dollar returns per hectare under pastoralism are two times higher than for ranching. Dollar returns per animal are a third higher.	Ruthenberg (1980) Behnke (1985a)
Ethiopia	The pastoral Borana system has higher returns of both energy and protein per hectare compared to industrialised ranching systems in Australia. Australian Northern Territory ranches only realise 16% of the energy and 30% of the protein per hectare compared to the Borana system.	Cossins (1985) Upton (1989) Cossins and Upton (1988)
Mali	Transhumant pastoral systems yield on average at least two times the amount of protein per hectare per year compared to both sedentary agropastoralists and ranchers in the US and Australia.	Breman and de Wit (1983) Wilson *et al*. (1983)

Source: Scoones (1995: 12)

Table 3. Summary of potential instruments and mechanisms for benefit-sharing of environmental goods and services

Environmental goods and services suitable for benefit-sharing	**Benefit-sharing among local users: facilitating collective action**	**Benefit-sharing between users at different levels: co-management or 'subsidiarity'**	**Beneficiary-compensation payments**	**Taxation**	**Infrastructure**	**Technology**
Ecological function values:						
• sustainable rangeland management	✓	✓	✓		✓	
• preservation of wildlife biodiversity	✓	✓	✓	✓		
• soil fertility enhancement/ nutrient cycling	✓	✓				✓
• carbon sequestration	✓	✓				✓
Direct use values:						
• landscape amenity		✓	✓			
• draught animal power					✓	
• household energy supply						✓
Option values:						
• animal genetic resources		✓	✓			

REFERENCES

Adams, J.S., and T.O. McShane. 1992. *The Myth of Wild Africa: Conservation Without Illusion*. New York & London: W.W. Norton & Co.

Baland, J.-M. and J.-P. Platteau. 1996. *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* Oxford: Clarendon Press

Bayer, W., and A. Waters-Bayer. 1995. 'Forage alternatives from range and field: pastoral forage management and improvement in the African drylands', in I. Scoones (ed), *Living with Uncertainty*. London: IT Publications

Behnke, R. 1994. Natural resource management in pastoral Africa. *Development Policy Review* 12: 5-27

Behnke, R., I. Scoones and C. Kerven (eds). 1993. *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas*. London: Overseas Development Institute

Brockington, D. and K. Homewood. 1996. 'Wildlife, pastoralists and science: debates concerning Mkomazi Game Reserve, Tanzania', in M. Leach and R. Mearns (eds), *The Lie of the Land: Challenging Received Wisdom on the African Environment*. Oxford: James Currey

Bullock, C. 1996. 'The benefits of landscape and ecological restoration: a discussion of some results from the Southern Uplands of Scotland'. Mimeo, Macaulay Land Use Research Institute, Aberdeen

Chambers, R. 1996 (forthcoming). *Whose Reality Counts? Putting the First Last*. London: IT Publications

Conant, F.P. 1982. 'Thorns paired, sharply recurved: cultural controls and rangeland quality in East Africa', in B. Spooner and H.S. Mann (eds), *Desertification and Development: Dryland Ecology in Social Perspective.* London & New York: Academic Press

Dalibard, C. 1995. Livestock's contribution to the protection of the environment. *World Animal Review* 84/85: 104-112

Daniels, S.E. 1996. 'The social and political forces shaping range management in the United States: vectors of change and social movements', in N. West (ed), *Rangelands in a Sustainable Biosphere* Vol. II. Proceedings of the Vth International Rangelands Congress. Denver: Society for Range Management

de Haan, C. 1994. An overview of the World Bank's involvement in pastoral development (plus commentaries). *Pastoral Development Network Paper* 36b. London: ODI

de Leeuw, P.N., and R. Reid. 1995. 'Impact of human activities and livestock on the African environment: an attempt to partition the pressure', pp29-39 in Wilson, R.T., S. Ehui and S. Mack (eds), *Livestock Development Strategies for Low Income Countries*. Rome: FAO, and Nairobi: ILRI

Delgado, C. L. 1978. 'Livestock versus foodgrain production in Southwest Upper Volta: a resource allocation analysis', in *Livestock Production and Marketing in the Entente States of West Africa*. Ann Arbor, Michigan: Centre for Research on Economic Development, University of Michigan.

Delgado, C.L. 1989. The changing economic context of mixed farming in savanna West Africa: a conceptual framework applied to Burkina Faso. *Quarterly Journal of International Agriculture* 28(3/4): 351-364

Durning, A.B., and H. Brough. 1991. Taking stock: animal farming and the environment. *Worldwatch Papers* 103. Washington, DC: Worldwatch Institute

FAO. 1991. *Proceedings of the International Workshop on Pastoralism and Socio-Economic Development, Mongolia*. Rome: FAO

Hendrickson, D., R. Mearns and J. Armon. 1996. Livestock raiding among the pastoral Turkana of Kenya: redistribution, predation and the links to famine. *IDS Bulletin* 27(3): 17-30

Hobbs, N.T., et al. 1996. Ungulate grazing in sagebrush grassland: mechanisms of resource competition. *Ecological Applications* 6(1): 200-217

Hofs, S., et al. 1993. 'Zur Integration van Tierhaltung in landwirtschaftliche Betriebs- und Haushaltssysteme in Afrika Südliche der Sahara', in J. Breburda (ed), *Ansatze für eine nachhaltige Landnutzung im östlichen Afrika*. Giessen, Germany: Giessener Beitrage zur Entwicklungsforschung

Homewood, K., and W.A. Rodgers. 1987. 'Pastoralism, conservation and the overgrazing controversy', in D. Anderson and R. Grove (eds), *Conservation in Africa: People, Policies and Practice*. Cambridge: Cambridge University Press

Huntsinger, L., and P. Hopkinson. 1996. Viewpoint - Sustaining rangeland landscapes: a social and ecological process. *Journal of Range Management* 49(2):167-173

IIED. 1994. *Whose Eden? An overview of community approaches to wildlife management*. Report to UK Overseas Development Administration. London: IIED

Jackson, J.M. 1992. Grazing rights: time for new outlook. *Natural Resources Journal* 32: 623-631

Krutilla, J.V., and C.J. Cicchetti. 1972. Evaluating benefits of environmental resources with special application to the Hell's Canyon. *Natural Resources Journal* 12(1): 1-29

Leach, G. and R. Mearns. 1988. *Beyond the Woodfuel Crisis: People, Land and Trees in Africa*. London: Earthscan Publications

Leach, M. and R. Mearns (eds). 1996. *The Lie of the Land: Challenging Received Wisdom on the African Environment*. Oxford: James Currey & Portsmouth, NH: Heinemann

Lindberg, K. 1991. *Policies for Maximising Ecotourism's Economic and Ecological Benefits.* Washington, DC: World Resources Institute

Little, P.D. 1996. Pastoralism, biodiversity and the shaping of savanna landscapes in East Africa. *Africa* 66(1): 37-51

McCabe, T., S. Perkin and C. Schofield. 1992. Can conservation and development be coupled among pastoral people? An examination of the Maasai of the Ngorongoro Conservation Area, Tanzania. *Human Organization* 51(4): 353-366

McDowell, R.E. 1977. *Ruminant Products: More Than Meat and Milk.* Morrilton, Arkansas: Winrock International Livestock Research and Training Center.

McIntire, J., D. Bourzat, and P. Pingali. 1992. *Crop-Livestock Interaction in Sub-Saharan Africa*. World Bank Regional and Sectoral Study. Washington, DC: The World Bank

Mearns, R. 1993. Territoriality and land tenure among Mongolian pastoralists: variation, continuity and change. *Nomadic Peoples* 33: 73-103.

Mearns, R. 1996a. Community, collective action and common grazing: the case of post-socialist Mongolia. *Journal of Development Studies* 32(3): 297-339

Mearns, R. 1996b. 'Commons and collectives: the role of social capital in Central Asia's land reforms'. Paper presented at Sixth Annual Conference of the International Association for the Study of Common Property, Berkeley, California, 5-8 June

Mearns, R., and J. Swift. 1996. 'Pasture tenure and management in the retreat from a centrally planned economy in Mongolia', in N. West (ed), *Rangelands in a Sustainable Biosphere* Vol. II. Proceedings of the Vth International Rangelands Congress. Denver: Society for Range Management

Moorehead, R. 1991. Structural Chaos: Community and State Management of Common Property in Mali. Unpublished PhD thesis, University of Sussex

Norton-Griffiths, M., and C. Southey. 1995. The opportunity costs of biodiversity conservation in Kenya. *Ecological Economics* 12(2): 125-139

PALD. 1993. Options for the reform of grazing land tenure in Mongolia. *Policy Options Paper* No. 1. Policy Alternatives for Livestock Development Project, Institute of Development Studies, University of Sussex.

Panin, A., and E. de Haen. 1989. Economic evaluation of animal traction: a comparative analysis of hoe and bullock farming systems in northern Ghana. *Quarterly Journal of International Agriculture* 28(1): 6-20

Perevolotsky, A. 1995. Conservation, reclamation and grazing in the northern Negev: contradictory or complementary concepts? *Pastoral Development Network Papers* 38a. London: ODI

Perrings, C, et al. 1995. 'Economic values of biodiversity', chapter 12 in UNEP, *Global Biodiversity Assessment*. Cambridge: Cambridge University Press for UNEP

Pimbert, M.P. and J.N. Pretty. 1995. Parks, People and Professionals: Putting 'Participation' into Protected Area Management. *UNRISD Discussion Paper* DP57. Geneva: UNRISD

Pretty, J.N. 1995. Participatory learning for sustainable agriculture. *World Development* 23(8): 1247-1263

Reid, R.S., and J.E. Ellis. 1995. Impacts of pastoralists on woodlands in South Turkana, Kenya: livestock-mediated tree recruitment. *Ecological Applications* 5(4): 978-992

Said Samantar, M. 1994. The Conditions for Successful Pastoral Common Property Regimes in Somalia. Unpublished PhD thesis, University of Sussex

Sandford, S. 1983. *The Management of Pastoral Development in the Third World.* Chichester: Wiley

Sansoucy, R. 1995. Livestock - a force for food security and sustainable development. *World Animal Review* 84/85: 5-17

Scoones, I. 1995. 'New directions in pastoral development in Africa', in I. Scoones (ed), *Living with Uncertainty*. London: IT Publications

Scoones, I. 1996. 'Integrating social sciences into rangeland management: chairperson's summary and comments', in N. West (ed), *Rangelands in a Sustainable Biosphere* Vol. II. Proceedings of the Vth International Rangelands Congress. Denver: Society for Range Management

Severson, K.E., and L.F. Debano. 1991. Influence of Spanish goats on vegetation and soils in Arizona chaparral. *Journal of Range Management* 44(2): 111-117

Shanmugaratnam, N., T. Vedeld, A. Mossige and M. Bovin. 1992. Resource management and pastoral institution building in the West African Sahel. *World Bank Discussion Papers* 175. Africa Technical Department Series. Washington, DC: The World Bank

Sheehy, D. 1995. Assessment of ecological and socio-economic factors influencing habitat use and large herbivore interactions in Mongolian pastoral ecosystems. Draft literature review. Union, Oregon: Eastern Oregon Agricultural Research Center, Oregon State University

Sheehy, D. and M. Vavra. 1996. Ungulate foraging areas on seasonal rangeland in northeastern Oregon. *Journal of Range Management* 49(1): 16-23

Singh, A.K., et al. 1995. Tractor vs. animal power: projections for Indian arid zone. *Agricultural Mechanisation in Asia, Africa and Latin America* 26(1): 16-20

Steinfeld, H., C. de Haan and H. Blackburn. 1996. Balancing Livestock and the Environment: Summary of the Results of a Multi-Donor Study. Mimeo. Washington, DC: The World Bank

Swallow, B. 1991. Common Property Regimes for African Rangeland Resources. Unpublished PhD thesis, University of Wisconsin-Madison

Swallow, B. 1995. 'Towards incentive-compatible mechanisms for enhanced carbon storage in the African drylands'. Paper presented at the International Workshop on Combatting Global Warming by Combatting Land Degradation, Nairobi, 4-8 September

Swallow, B. 1996. 'Understanding the multiple functions of common property regimes: examples from rangelands'. Paper presented at Sixth Annual Conference of the International Association for the Study of Common Property, Berkeley, California, 5-8 June

Swallow, B. and D.W.Bromley. 1994. Co-management or no management: the prospects for internal governance of common property regimes through dynamic contracts. *Oxford Agrarian Studies* 22(1): 3-16

Swift, J. 1995. 'Dynamic ecological systems and the administration of pastoral development', in I. Scoones (ed), *Living with Uncertainty*. London: IT Publications

Swift, J. 1996. 'Desertification: narratives, winners and losers', in M. Leach and R. Mearns (eds), *The Lie of the Land: Challenging Received Wisdom on the African Environment*. Oxford: James Currey

Thébaud, B., H. Grell and S. Miehe. 1995. Recognising the effectiveness of traditional pastoral practices: lessons from a controlled grazing experiment in northern Senegal. *Drylands Programme Issues Papers* 55. London: IIED

Thompson, M. 1993. Good science for public policy. *Journal of International Development* 5(6): 669-679

Tiffen, M., M. Mortimore, and F. Gichuki. 1994. *More People, Less Erosion: Environment Recovery in Kenya*. Chichester: Wiley

Toulmin, C. 1991. Natural resource management at the local level: will this bring food security to the Sahel? *IDS Bulletin* 22(3): 22-30

Toulmin, C. 1992a. *Cattle, Women and Wells: Managing Household Survival in the Sahel*. Oxford: Clarendon Press

Toulmin, C. 1992b. Herding contracts: for better or worse? *ILEIA Newsletter* 8(3): 8-9

Vandasselaar, A.V., and Lantinga, E.A. 1995. Modelling the carbon cycle of grassland in the Netherlands under various management strategies and environmental conditions. *Netherlands Journal of Agricultural Science* 43(2): 183-194

Wells, M. 1996. 'Social-economic strategies to sustainably use, conserve and share the benefits of biodiversity', chapter 13.5 in UNEP, *Global Biodiversity Assessment*. Cambridge: Cambridge University Press for UNEP

Wells, M.P., and K. Brandon. 1992. *People and Parks: Linking Protected Area Management with Local Communities*. Washington, DC: The World Bank, WWF & USAID

West, N.E. 1993. Biodiversity of rangelands. *Journal of Range Management* 46(1): 2-13

Western, D., and V. Finch. 1986. Cattle and pastoralism: survival and production in arid lands. *Human Ecology* 14: 77-94

Western, D., R. M. Wright and S. Strum (eds). 1994. *Natural Connections: Perspectives in Community-Based Conservation*. Washington, DC: Island Press

White, T.A., and C.F. Runge. 1995. The emergence and evolution of collective action: lessons from watershed management in Haiti. *World Development* 23(10): 1683-1698

Wilson, P.N., and G.D. Thompson. 1993. Common property and uncertainty: compensating coalitions by Mexico's *ejidatarios*. *Economic Development and Cultural Change* 41(2): 299-318

Winrock International. 1992. *Assessment of Animal Agriculture in Sub-Saharan Africa*. Morrilton, Arkansas: Winrock

Young, M.D. 1992. *Sustainable Investment and Resource Use: Equity, Environmental Integrity and Economic Efficiency*. Carnforth: Parthenon for UNESCO

Young, M.D. 1996. Paper prepared for World Bank/FAO Workshop, 'Balancing Livestock and Environment', Washington, DC, 27-28 September

Young, M.D., and O.T. Solbrig. 1992. Savanna management for ecological sustainability, economic profit and social equity. *MAB Digests* 13. Paris: UNESCO